

## **UWB Two-Cluster AOA Tracking Prototype System Design**

### **Abstract**

This presentation discusses a design effort for a prototype ultra-wideband (UWB) tracking system that is currently under development at NASA Johnson Space Center (JSC). The system is being studied for use in tracking of lunar/Mars rovers during early exploration missions when satellite navigation systems are not available. The UWB technology is exploited to implement the tracking system due to its properties such as fine time resolution, low power spectral density and multipath immunity. A two-cluster prototype design using commercially available UWB radios is employed to implement the Angle of Arrival (AOA) tracking methodology in this design effort. In order to increase the tracking range, low noise amplifiers (LNA) and high gain horns are used at the receiving sides. Field tests were conducted jointly with the Science and Crew Operation Utility Testbed (SCOUT) vehicle near the Meteor Crater in Arizona to test the tracking capability for a moving target in an operational environment. These tests demonstrate that the UWB tracking system can co-exist with other on-board radio frequency (RF) communication systems (such as Global Positioning System (GPS), video, voice and telemetry systems), and that a tracking resolution less than 1% of the range can be achieved.

# UWB Two-Cluster AOA Tracking Prototype System Design



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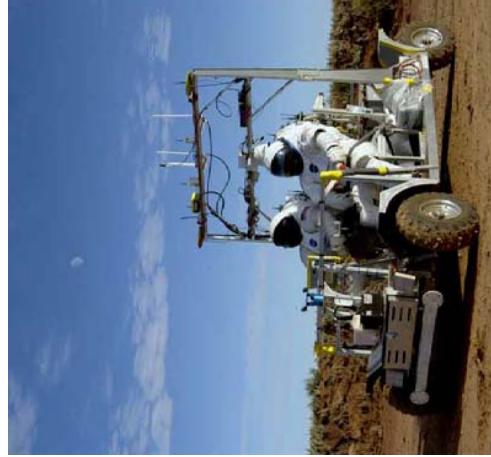
**NASA Johnson Space Center**

# Outline

- Motivation (Tracking for Space Exploration)
- Prototype System Design Overview
- System Design Philosophy
- Key Hardware – UWB PulsON 200 Radios
- Laboratory Experiment to Test CCPD (Cross-Correlation Peak Detection)
- Methods to Increase the Tracking Range
- Field Tests with SCOUT Vehicle
- Conclusion and Future Work

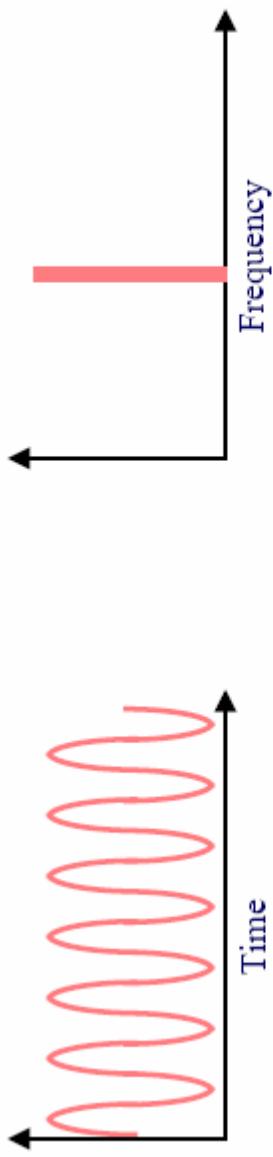
# Tracking for Space Exploration

- ★ Tracking rovers and astronauts for early Lunar/Mars exploration missions when navigation satellites are not available
- ★ SCOUT vehicle as testbed for Lunar/Mars rover prototype

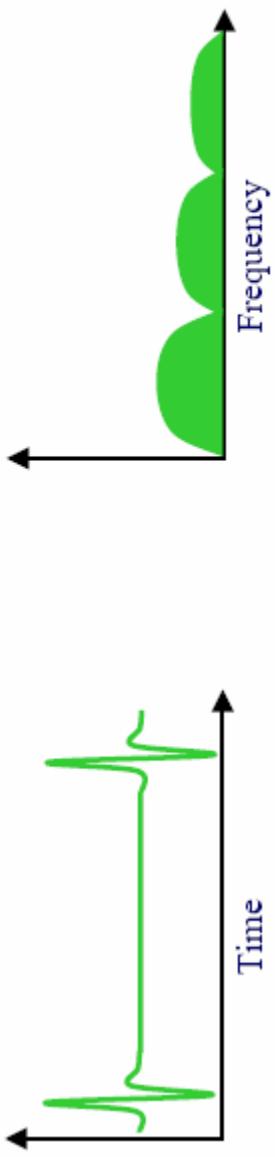


# UWB Fine Time Resolution

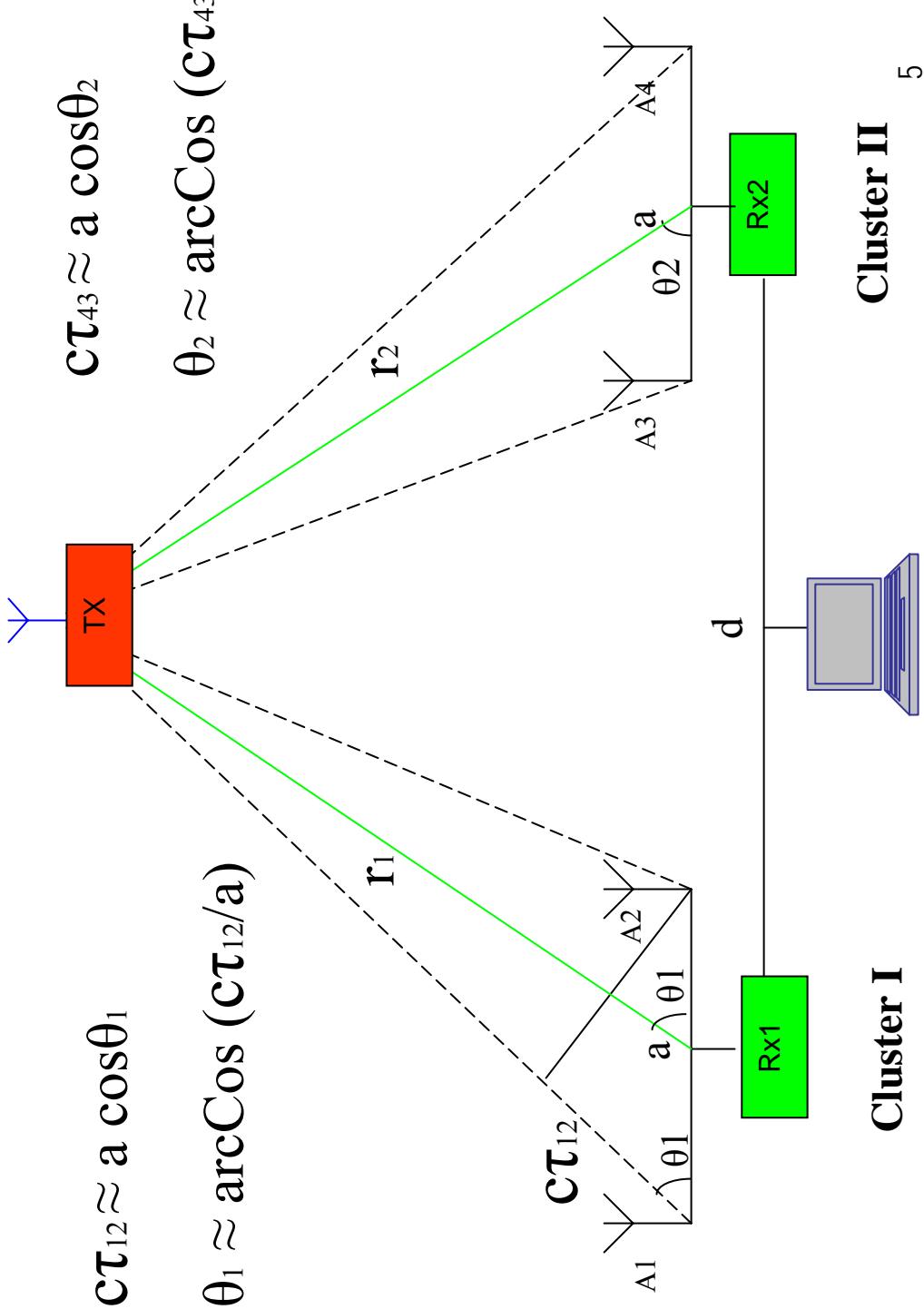
## Sinusoidal, Narrowband



## Impulse, Ultra-Wideband



# Two Cluster Design



## Advantages of Using TDOA Data

- No synchronization between Tx and Rx
- Simplex (one-way) data estimation
- Cross-correlation works well to obtain TDOA (Time Difference of Arrival)

# Lab Experiments ( UWB PulsON 200 Radio)

- ★ Signal Generator



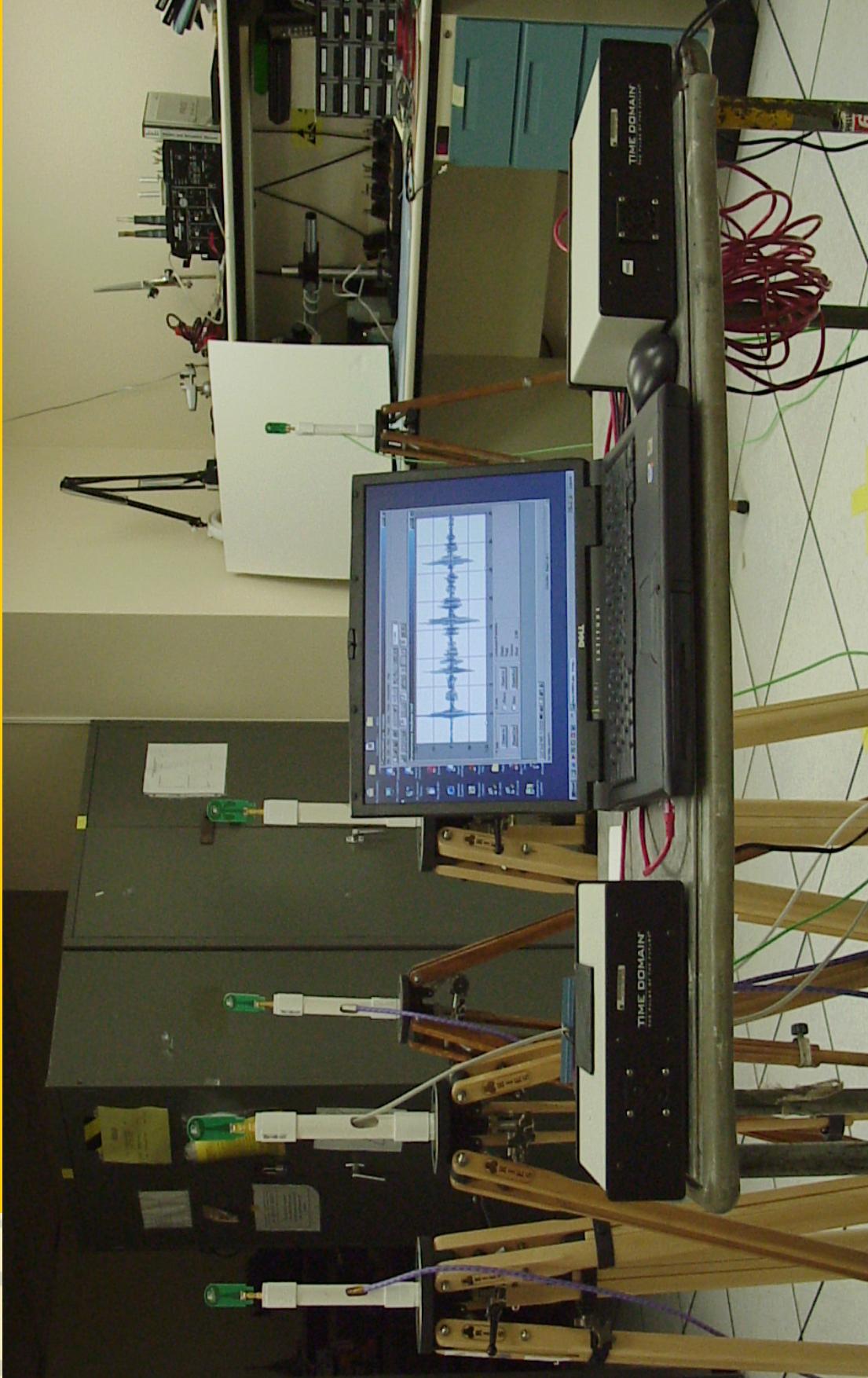
- ★ Evaluation Kit



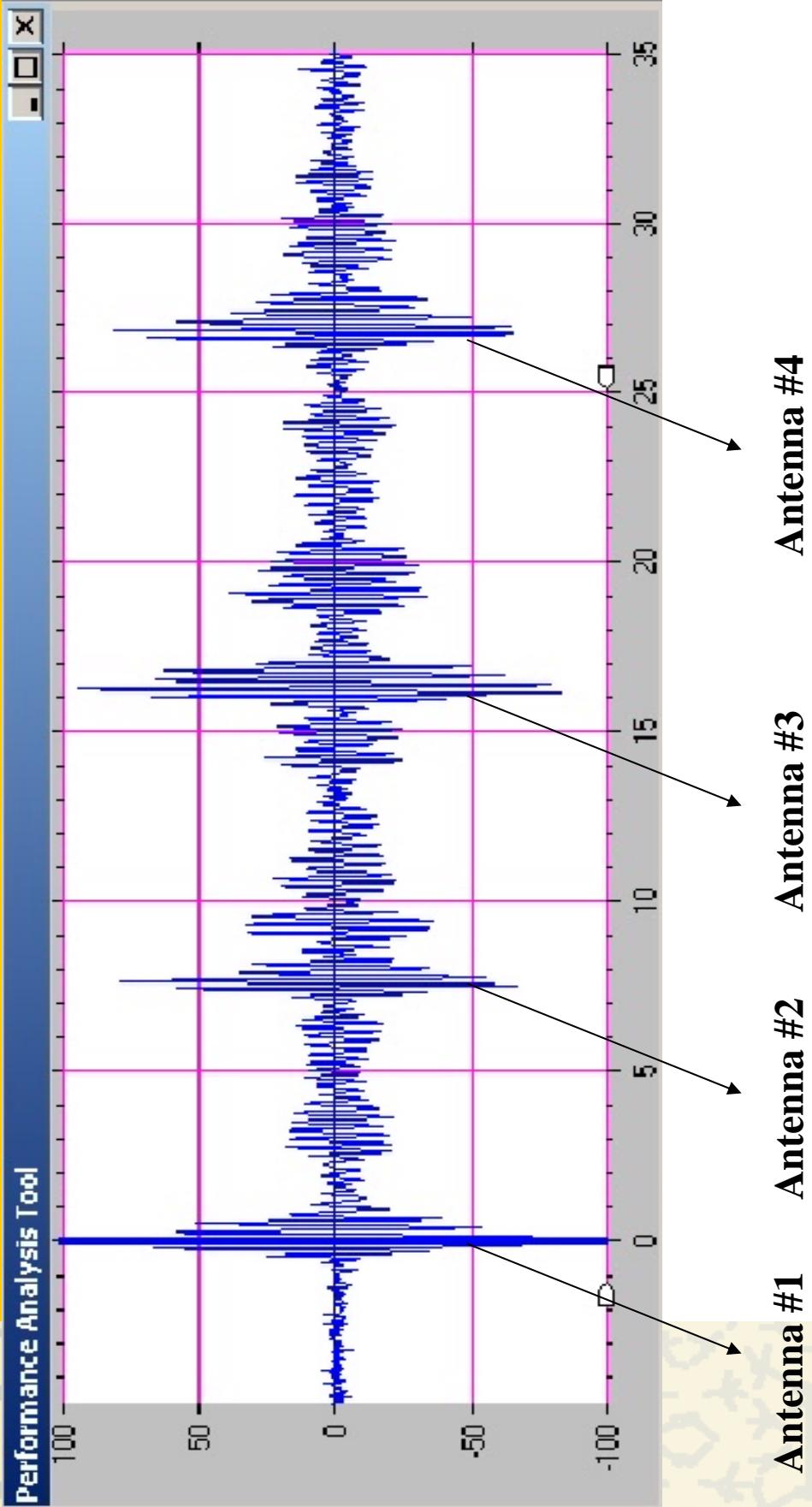
# PulSoN 200 Specifications

- ★ PRF (Pulse Repetition Frequency): 9.6 MHz
- ★ 8 data rates: 75 kbps, 150 kbps, ..., 4.8 Mbps, 9.6 Mbps
- ★ Center Frequency (radiated): approximately 4.7 GHz
- ★ Bandwidth (10 dB radiated): 3.2 GHz
- ★ EIRP: -11.5 dBm
- ★ Co-exists with all US-based wireless systems (including GPS)
- ★ Superior multipath immunity as a result of UWB-physics
- ★ Fine resolution tracking
- ★ FCC Compliant - FCC 15.517, 15.209
- ★ Diamond Dipole Antenna
- ★ StrongARM™ Microprocessor for Embedded Applications Development

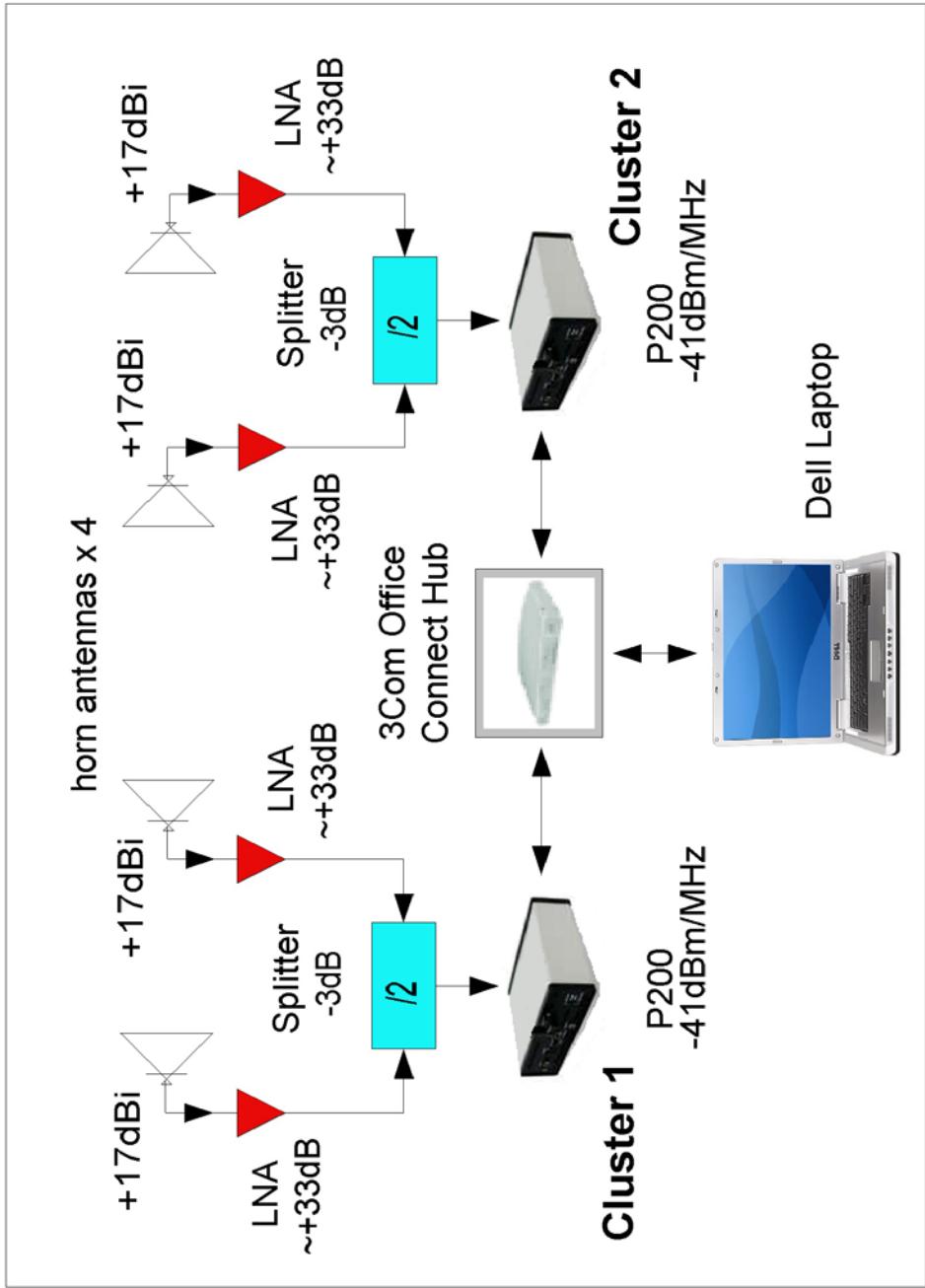
# Lab Experiments (setup)



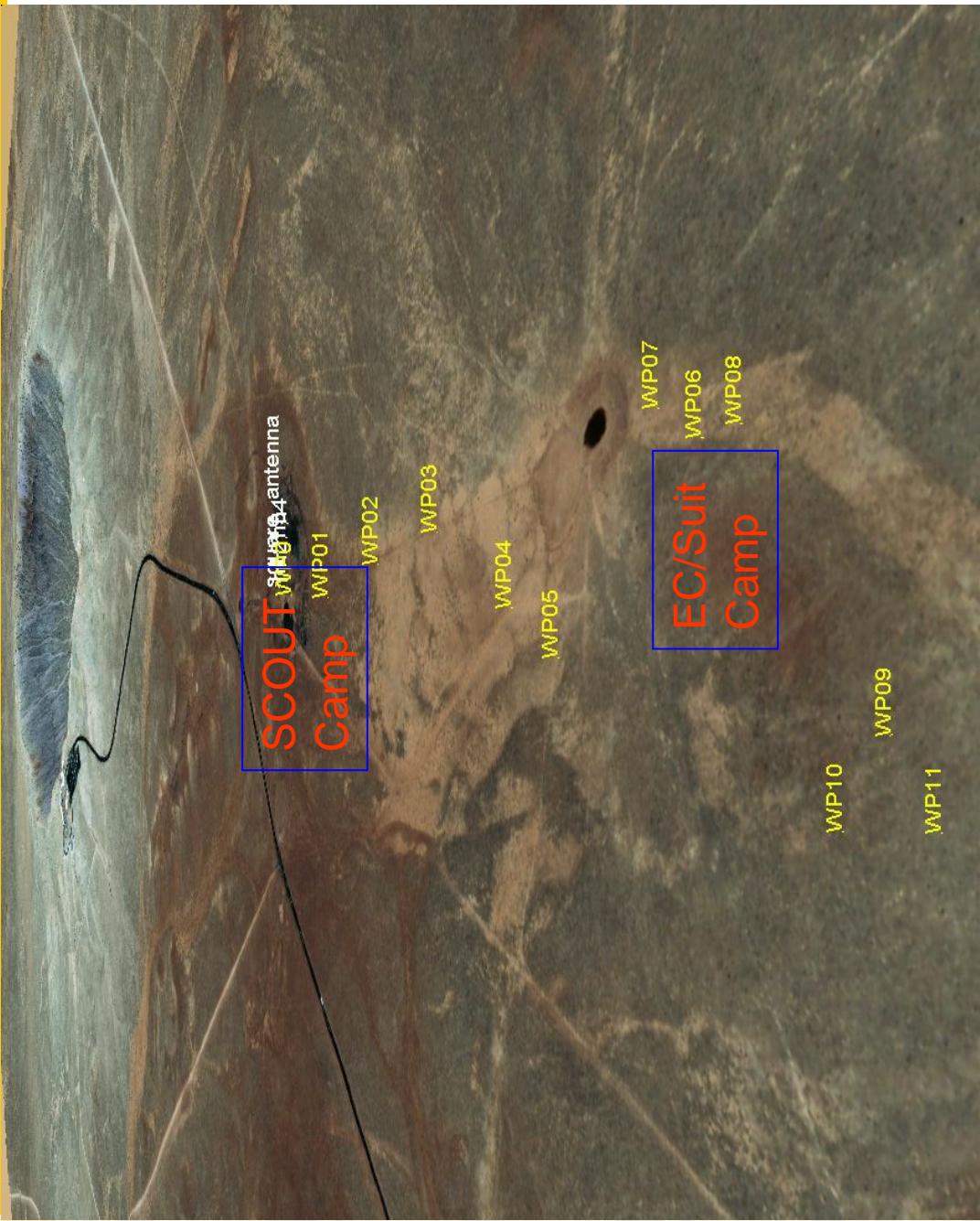
# Lab Experiments ( Four Antenna Scheme)



# Two-Cluster Tracking Baseline



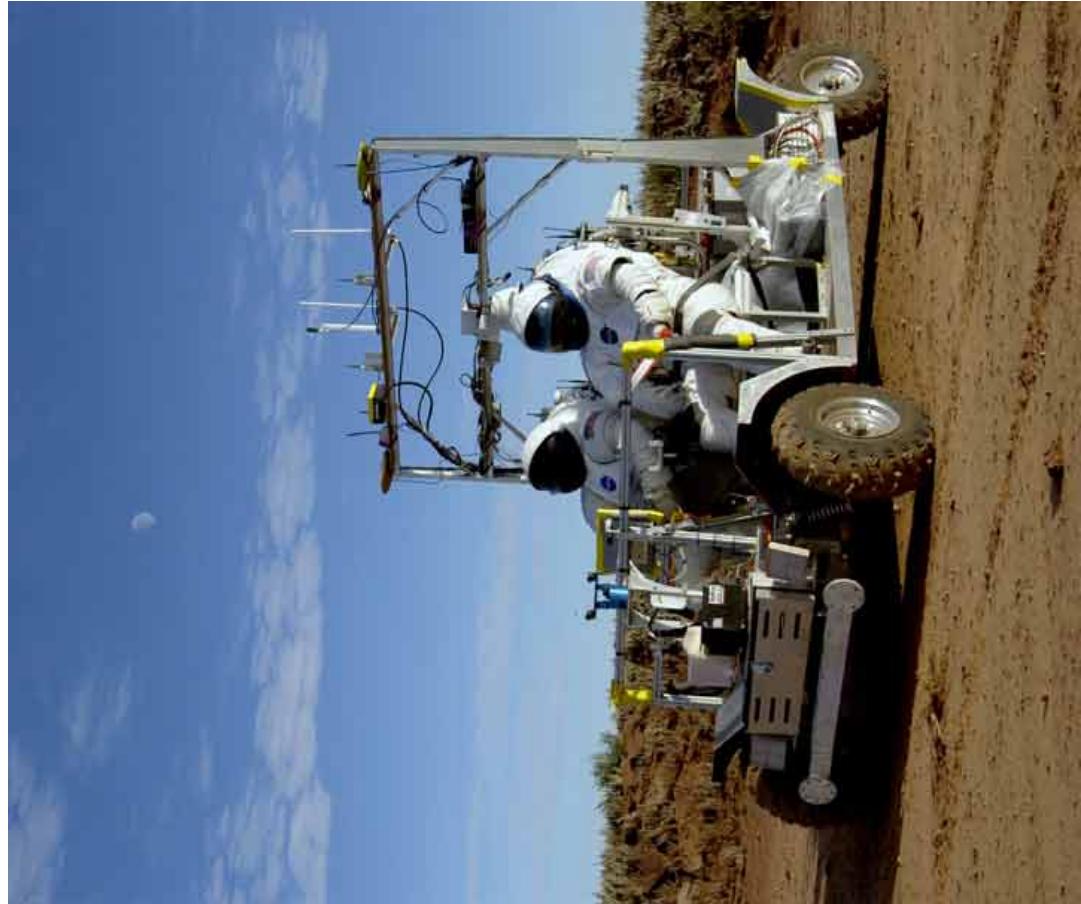
# Test Site (Arizona Meteor Crater)



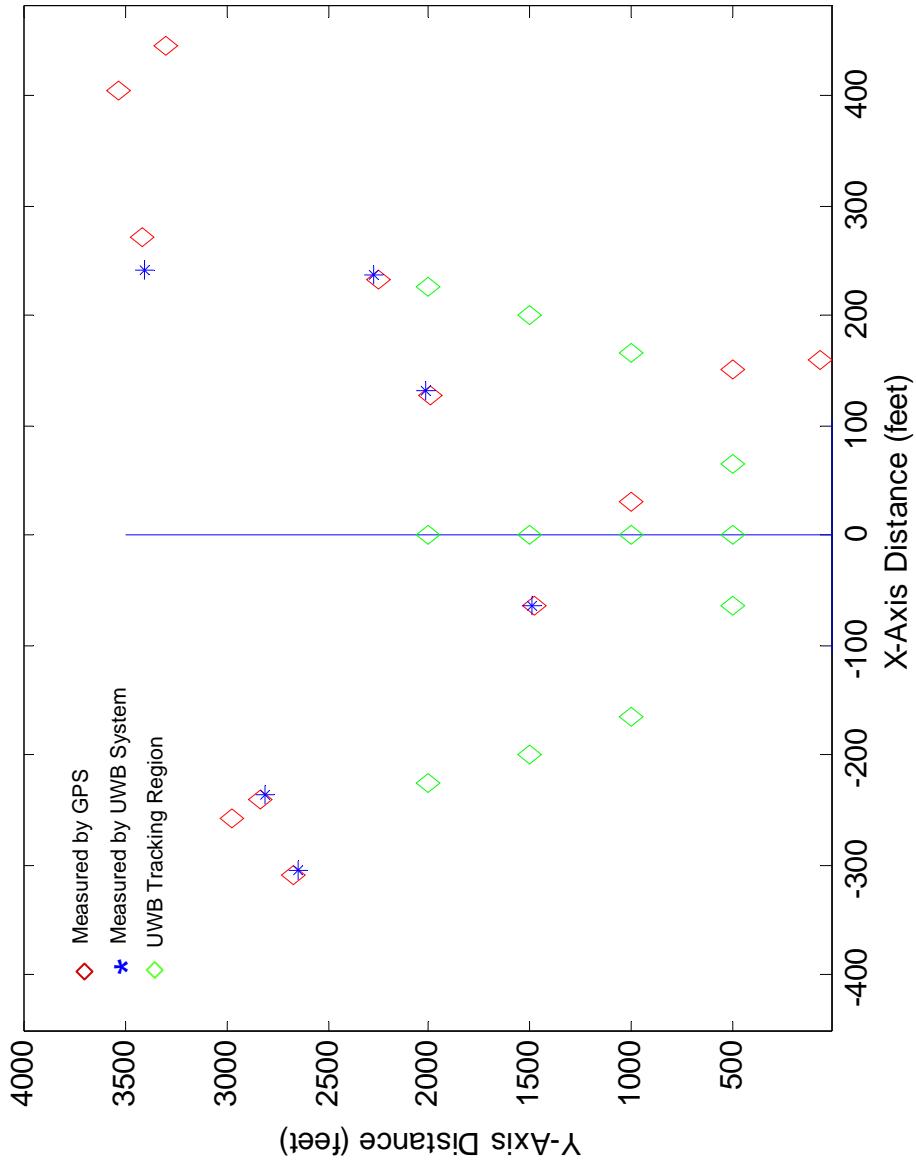
# Two-Cluster Tracking Baseline Set-up



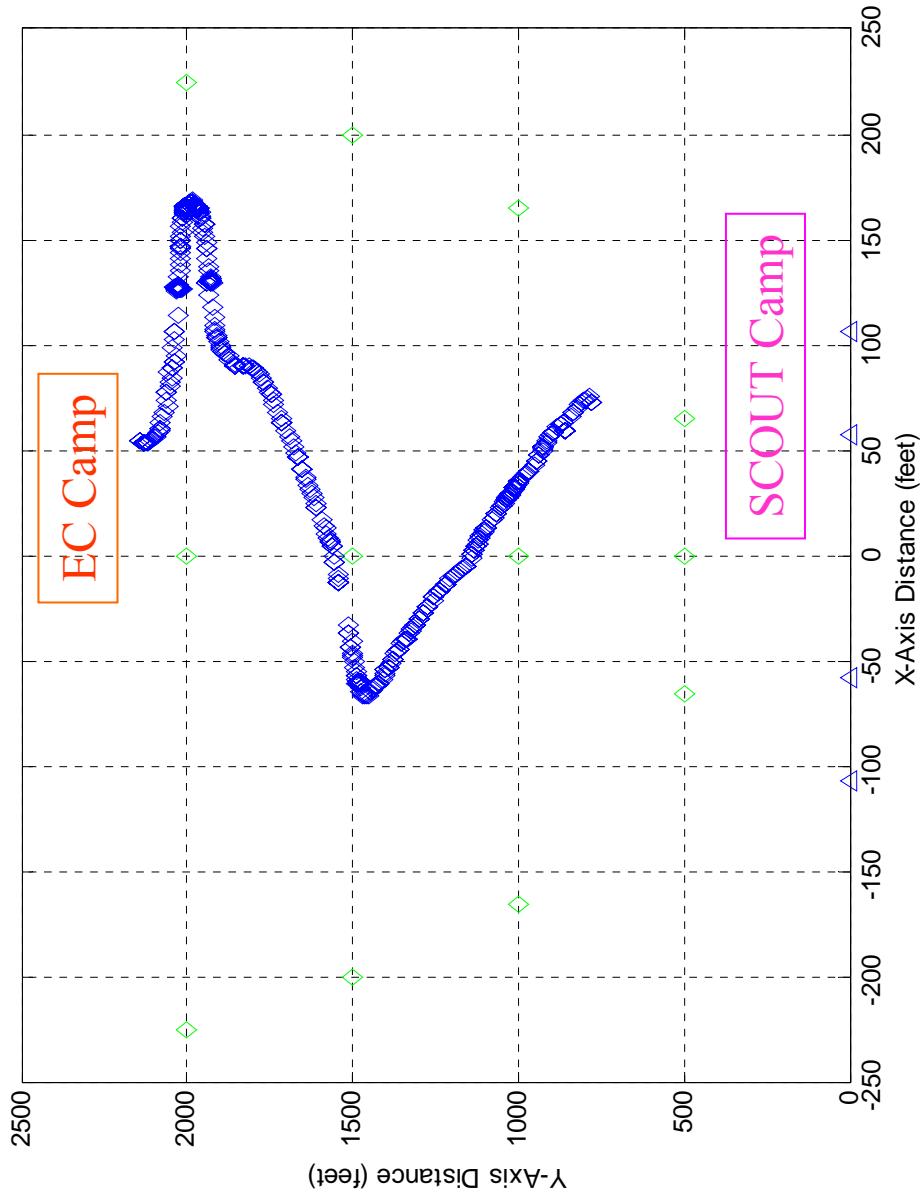
# Tracking Target (SCOUT)



# Tracking Results (Accuracy)



# Tracking Results (Trajectory)



Trajectory: UWB System tracking the SCOUT vehicle

# Conclusion

- ★ A UWB AOA Two-Cluster tracking scheme has been established.
- ★ The lab experiments show that CCPD technique can obtain fine TDOA estimates.
- ★ The UWB tracking system can co-exist with other RF communication systems on-board SCOUT.
- ★ A tracking resolution less than 1% of the range (range up to 2000 feet) has been successfully demonstrated.
- ★ A moving target can be tracked in real time (update rate=3Hz).
- ★ The field tests demonstrate the tracking capability of the UWB technology.

## Future Work

- High data rate communications (480 Mbps) for EVA and IVA crew communications (video, voice, command, telemetry.)
- Integration of comm. and tracking system
- UWB RFID for ISS inventory tracking
- UWB Software Defined Radio Design
- Ground penetrating radar for planet exploration